# EXPERIENCE WITH AN ADVANCED INSTRUMENT TO MONITOR UNBURNED CARBON IN FLY ASH FROM COAL-FIRED POWER PLANTS

M. Graziadio
A. Cipriano
E-mail: graziadio@pte.enel.it
Tel: 011-39-050-535621
Fax: 011-39-050-535521
ENEL Produzione – Ricerca
Via A. Pisano, 120 Pisa (Italy)

R. Turato
ENEL
PDT-NES/Porto Marghera Power Station

M. McElroy
Electric Power Technologies, Inc.
5270 Neil Road
Reno, Nevada 89502

## SUMMARY

In 1994 ENEL began development of a microwave-based instrument, named MITER 1600, for on-line measurement of the unburned carbon (UBC) content of coal fly ash. An accurate, real-time measure of UBC was of particular importance for ENEL power plants in order to monitor and maintain ash carbon content at levels suitable for ash utilization by the cement industry and avoid the high cost of ash disposal.

MITER 1600 uses a single-point extractive sampling system for collecting fly ash samples from the boiler exhaust duct. The basic principle of operation involves microwave irradiation of a sample cell containing the ash, and analysis of the reflected signal. The power reflection coefficient (ratio of incident microwave power to the reflected power) is correlated to the UBC. Prototypes of MITER 1600 have been tested in several power plant sites in Italy and the U.K.

The first extensive demonstration was carried out in 1997 on a 320 $MW_e$ boiler. During 3000 hours of operation, 32,000 measuring cycles were performed automatically by MITER 1600. The instrument was very reliable, despite the adverse ambient conditions (night-to-day thermal shocks, plant vibrations, dust and humidity). The measurements clarified the sensitivity of UBC to normal variations in boiler operating parameters (e.g., load, excess $O_2$, burners out of service, and sootblowing), and demonstrated the value of MITER in diagnosing abnormal and potentially unsafe boiler operating conditions.

At a 35 $MW_e$ boiler MITER 1600 has been operating without problems since 1997. With the aid of MITER the cause of anomalous increases in stack opacity during boiler sootblowing was

diagnosed and remedial actions were implemented on each of four similar boilers at the station. The high opacity was found to be due to changes in mean furnace temperature during furnace sootblowing, which effected the temperature and behaviour of ash deposits. As a consequence, boiler sootblowing practices were modified, including reduced sootblowing duration and continuous monitoring of UBC and flue gas temperature during sootblowing. The new approach reduces UBC 3-4 % (absolute), while maintaining low excess $O_2$ and $NO_x$ levels under the regulated limit. Fly ash is now suitable for the cement industry (i.e., UBC less than 5%) in all situations, even when burning coals with very low ash content. In this application, MITER 1600 was the key factor in establishing new operating procedures that result in cost savings of $225,000 (US) per year for the power station due to reduced sootblowing steam consumption.

Recently, low-$NO_x$ combustion modifications have been adopted at ENEL coal-fired boilers. This has increased the variability and ranges of UBC in the ash. Concurrently, ENEL began to fire more varieties of coals, which were often mixed in unknown proportions at power stations. These conditions made it necessary to refine MITER technology to adapt to a wider range of UBC and coal ash properties, without requiring re-calibration with changes in coal type. ENEL has now developed and patented a new, lower-cost version of the instrument, named MITER, which satisfies these requirements. The new MITER is based on a modified microwave technique, in which the sensor moves over the sample cell in order to analyze different locations of the ash sample. Selected microwave parameters are measured at each location and the results are synthesized to obtain a precise value of the UBC level. Laboratory trials have shown that MITER has a dynamic range of 0-25% UBC with mean measurement errors of $\pm$ 0.5 % (absolute), when a single type of coal is burned. When blends of coals are used, it is possible to employ a "coal-independent" response correlation, with less accuracy ($\pm$ 1.5 % absolute) but no need of re-calibration.

MITER consists of two units: the measurement head/sample probe assembly and the control cabinet. These components are easy to transport and can usually be commissioned in a single day. The prototype of the new MITER was tested at Georgia Power Company's Plant Hammond from September 1999 to February 2000. This test confirmed instrument sensitivity and indicated further potential design refinements. Commercial specifications for MITER will be finalized during follow-up field trials in Italy. It is planned that commercial versions of MITER will be installed in several ENEL power stations during Year 2000, and one will be applied in Greece as part of an international project sponsored by the E.U.